New approaches for evaluation and treatment of appendicitis

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Disclosures

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- I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.
Appendicitis: scope of the disease

- Over 70,000 cases annually in children in USA
- Lifetime risk of appendicitis: 9% for boys, 7% for girls
- Peak incidence 12 to 18 years
Burden of Appendectomy: Hospital-Acquired Infection
Burden of Appendectomy: Cost Variation
Objectives

- Why do children get appendicitis?
- What are typical presenting features?
- How do we make the diagnosis?
- How do we decide WHETHER to operate?
- How do we decide WHEN to operate?
- What is the difference in how we approach perforated vs non-perforated appendicitis?
- Does every child with appendicitis actually need surgery?
Why does appendicitis occur?
HI, MY NAME IS APPENDIX, AND SOMETIMES I GET SO ANGRY I COULD BURST!

YOU HAVE A PURPOSE! MAYBE.

NON-ESSENTIAL ORGAN SUPPORT GROUP
Who is more likely to present with perforated appendicitis?

A. Younger patients
B. Patients with developmental delay
C. Uninsured patients
D. Minorities
E. All of the above
More likely to present with perforated appendicitis:

- Perforation rates are reported from 20%-80% in children
- Younger kids
  - 82% in children under 5
  - Nearly 100% of 1-year-olds
- Developmental delay
- Uninsured
- Minorities

Which of the following symptoms is LEAST likely to be consistent with appendicitis?

A. Fever
B. Nausea/vomiting
C. Diarrhea
D. Peri-umbilical pain
E. Anorexia
How do children present with appendicitis?

- Pain starts peri-umbilical and then migrates to RLQ
- Pain starts insidiously, is persistent and worsens over time
- Pain is worse with movement
- Fever, nausea with or without vomiting, and anorexia
- Features suggesting *alternative* diagnoses:
  - Waxing and waning pain
  - **Diarrhea**, cough, sore throat, myalgias, rhinorrhea and sick contacts
  - (BUT there are patients with many of the above symptoms who DO have appendicitis!)
Differential diagnosis

- Virus
- Pneumonia
- Constipation
- In adolescent females:
  - PID
  - Ovarian cyst
  - Mittelschmertz

It's not gas
Just Appendicitis
Approach to physical exam in suspected appendicitis

- Child does NOT want to move around
- Focal tenderness
- Percussion of the abdomen causes discomfort (this is better than rebound tenderness)
- Psoas, obturator, Rovsing’s, heel strike
- Watch them walk around
"Does this child have appendicitis?" Meta-Analysis

- Fever
  - If present, LR 3.4 (2.4-4.8)
  - If absent, LR 0.32 (0.16-0.64)
- Rebound tenderness
  - If present, LR 3.0 (2.3-3.9)
  - If absent, LR 0.28 (0.14-0.55)
- Migration of pain LR range 1.9-3.1
- RLQ pain LR 1.2 (1.0-1.5)
- WBC less than 10 LR 0.22 (0.17-0.30)
- ANC less than 6750 LR, 0.06 (0.03-0.16)

### Alvarado score for appendicitis

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migratory right iliac fossa pain</td>
<td>1</td>
</tr>
<tr>
<td>Nausea / Vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td><strong>Signs</strong></td>
<td></td>
</tr>
<tr>
<td>Tenderness in right iliac fossa</td>
<td>2</td>
</tr>
<tr>
<td>Rebound tenderness in right iliac fossa</td>
<td>1</td>
</tr>
<tr>
<td>Elevated temperature</td>
<td>1</td>
</tr>
<tr>
<td><strong>Laboratory findings</strong></td>
<td></td>
</tr>
<tr>
<td>Leucocytosis</td>
<td>2</td>
</tr>
<tr>
<td>Shift to the left of neutrophils</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10</td>
</tr>
</tbody>
</table>

5-6 → Possible  
7-8 → Probable  
> 9 → Very probable
You are seeing a child in your office with 1-day history of RLQ pain. You are suspicious for appendicitis. Where would you send the patient?

A. Emergency room
B. Same day outpatient surgery clinic
C. CT scan
D. Ultrasound
E. Other
What to do with suspected appendicitis

- **Obtain imaging vs send to ED?**
  - If any suspicion for viral syndrome with dehydration → to ED
  - If VERY HIGH suspicion for appendicitis and good pediatric radiologist is available, consider sending child for ultrasound
Abdominal pain, r/o appendicitis

Strong suspicion on H/PE
1. IV placed, 20 cc/kg bolus, CBC
2. Surgical consult within one hour

Operating Room/ further w/u per surgeon

Equivocal history/ physical exam
1. IV placed, 20 cc/kg bolus, CBC
2. Re-examine, surgical consult within one hour if still tender

Further workup and imaging* in consultation with Surgery team
What is the best way to image the appendix?

A. CT scan
B. Ultrasound
C. MRI
D. Abdominal X ray
E. Other
Ultrasound
Summary of approach to imaging

- Ultrasound is good if you have a high pretest probability, good radiologist, thin patient
- MRI is good if you are in a center that uses it routinely to evaluate children with appendicitis
- CT scan is best if above criteria are not met

Alternative to imaging:
- OBSERVATION
Once diagnosis of appendicitis has been established...

- **Non-ruptured**
  - Short duration of symptoms, no suggestion of rupture on imaging
  - Start antibiotics
  - Perform appendectomy

- **Ruptured**
  - Have radiology evaluate for drainable fluid collection
  - Antibiotics
  - Operation if above management fails
Once diagnosis of appendicitis has been established...

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- **Ruptured**
  - Have radiology evaluate for drainable fluid collection
  - Antibiotics
  - Operation if above management fails
When should appendectomy be performed in a patient with non-ruptured acute appendicitis?

A. Immediately after diagnosis

B. Within first 24 hours of hospital stay, once appropriate antibiotics and IVF resuscitation have been provided

C. After completion of a one-week course of antibiotics

D. It is reasonable to treat these patients with antibiotics alone and not perform an appendectomy
Is the appendix a ticking time bomb?

- Traditional teaching: appendicitis is an emergency and should be treated with surgery immediately upon diagnosis
- Several studies have now shown that delays of 12 hours up to 48 hours do not increase risk of perforation
- Current standard: admit, IVF resuscitation, antibiotics, appendectomy during daylight hours
Port placement
Lap appy with Endo-loops
Lap appy with stapler
Open appendectomy
Appendix with fecolith
Laparoscopic vs open appendectomy?

- Laparoscopy is standard of care
- Lower complication rate
- Less scar
- Less pain
- Ability to evaluate other intra-abdominal organs if the appendix looks normal
  - Gallbladder
  - Ovaries
  - Inguinal canal

Post-op course

- Most patients can go home on the day of surgery
- Recovery is usually quick
- Back to school within a week, sports within 2 weeks
- Very low risk surgery with good outcomes
- Risk of infection is about 5%: at port sites or in abdomen
You see a 7 year old male in your office with 1-day history of abdominal pain now localized to RLQ with focal guarding and poor appetite. You send him for ultrasound and it shows appendicitis. His mother has heard about some new research and wants to know if you would recommend just treating with antibiotics rather than surgery. How would you counsel this mom?

A. This data is preliminary and surgery is still standard of care
B. This may be a reasonable option for her son and she should discuss it with her surgeon
C. If it were your son you wouldn’t let him have surgery
D. Other??
Do all patients with appendicitis require surgery?

- Pilot study at Nationwide Children’s Hospital
- 102 patients
  - 7 to 17 years of age
  - Uncomplicated appendicitis defined by:
    - Abdominal pain ≤ 48 hours,
    - White blood cell count ≤ 18,000
    - Ultrasound or CT scan showing appendicitis with an appendix ≤ 1.1 centimeter thick and no evidence of abscess or fecalith
- Patients and families chose to have appendectomy or antibiotics alone
- Non-operative management: at least 24 hours of in-hospital observation and IV antibiotics until symptoms improved, followed by completion of 10 days of treatment with antibiotics by mouth

Results of non-operative management

- 65 families chose appendectomy; 37 families chose non-operative management.
- Success rate of non-operative management (defined as not undergoing an appendectomy): 89% at 30 days; 76% at 1 year.
- The 24% who failed did NOT have a higher rate of ruptured appendicitis compared to the patients who had immediate appendectomy.
- 1 year follow-up: the children managed non-operatively compared with the surgery group had fewer disability days (8 vs. 21 days), lower appendicitis-related health care costs (median, $4,219 vs. $5,029), and no difference in health-related quality of life.
Non-Operative Treatment of Appendicitis: Rationale

- Appendectomy is invasive
- Children may miss up to two weeks of school/activities
- Caregivers miss work
- Postop complications after appendectomy for uncomplicated appendicitis: 5-10%
- Serious complications (reoperations or readmissions) 1-7%
- Adult data suggest one-year success rates of 63-85%; no difference in rates of complicated appendicitis
Meta-analysis of 10 articles reporting 413 children receiving non-operative treatment (NOT) for appendicitis – all published in past 10 years
- 5 comparative
- 1 RCT
- 4 case series of NOT
Interpreting meta-analyses: Forest plot

- Favors antibiotics
- Favors appendectomy

Does not cross vertical line = significant difference
Overall success of NOT: 97% during initial episode
Incidence of recurrent appendicitis during follow-up period (range 2-51 months)

<table>
<thead>
<tr>
<th>Study</th>
<th>Estimate (95% C.I.) Recurrence / Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abes 2007</td>
<td>0.13 (0.00 to 0.31) / 2/15</td>
</tr>
<tr>
<td>Armstrong 2014</td>
<td>0.18 (0.00 to 0.41) / 2/11</td>
</tr>
<tr>
<td>Gorter 2015</td>
<td>0.02 (0.00 to 0.07) / 0/25</td>
</tr>
<tr>
<td>Kaneko 2004</td>
<td>0.27 (0.09 to 0.46) / 6/22</td>
</tr>
<tr>
<td>Koike 2014</td>
<td>0.19 (0.12 to 0.26) / 24/125</td>
</tr>
<tr>
<td>Steiner 2015</td>
<td>0.02 (0.00 to 0.07) / 1/42</td>
</tr>
<tr>
<td>Svensson 2014</td>
<td>0.09 (0.00 to 0.20) / 2/23</td>
</tr>
<tr>
<td>Tanaka 2015</td>
<td>0.29 (0.18 to 0.39) / 22/77</td>
</tr>
<tr>
<td>Hartwich 2015</td>
<td>0.10 (0.00 to 0.22) / 2/21</td>
</tr>
<tr>
<td>Minneci 2015</td>
<td>0.20 (0.07 to 0.33) / 7/35</td>
</tr>
<tr>
<td>Overall (I² = 79.95 %, P &lt; .01)</td>
<td>0.14 (0.07 to 0.21) / 68/396</td>
</tr>
</tbody>
</table>
Long term efficacy of NOT (no appendectomy at end of follow-up period)

<table>
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<tr>
<th>Study</th>
<th>Estimate (95% C.I.)</th>
<th>Success / Total</th>
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<tr>
<td>Abes 2007</td>
<td>0.81 (0.62 to 1.00)</td>
<td>13/16</td>
</tr>
<tr>
<td>Armstrong 2014</td>
<td>0.75 (0.51 to 0.99)</td>
<td>9/12</td>
</tr>
<tr>
<td>Gorter 2015</td>
<td>0.92 (0.81 to 1.00)</td>
<td>23/25</td>
</tr>
<tr>
<td>Kaneko 2004</td>
<td>0.73 (0.54 to 0.91)</td>
<td>16/22</td>
</tr>
<tr>
<td>Koike 2014</td>
<td>0.85 (0.79 to 0.91)</td>
<td>111/130</td>
</tr>
<tr>
<td>Steiner 2015</td>
<td>0.89 (0.80 to 0.98)</td>
<td>40/45</td>
</tr>
<tr>
<td>Svensson 2014</td>
<td>0.62 (0.43 to 0.82)</td>
<td>15/24</td>
</tr>
<tr>
<td>Tanaka 2015</td>
<td>0.82 (0.74 to 0.91)</td>
<td>64/78</td>
</tr>
<tr>
<td>Hartwich 2015</td>
<td>0.71 (0.53 to 0.89)</td>
<td>17/24</td>
</tr>
<tr>
<td>Minneci 2015</td>
<td>0.76 (0.62 to 0.90)</td>
<td>28/37</td>
</tr>
<tr>
<td>Overall (i² = 34.11%, P = .14)</td>
<td>0.82 (0.77 to 0.87)</td>
<td>336/413</td>
</tr>
</tbody>
</table>
LOS shortened by about 0.5 days in those undergoing appendectomy compared to NOT

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Non-operative treatment</th>
<th>Appendectomy</th>
<th>Mean Difference Random, 95% CI [Days]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armstrong 2014</td>
<td>1.5 1</td>
<td>1.3 0.5</td>
<td>0.20 [-0.43, 0.83]</td>
</tr>
<tr>
<td>Minneci 2015</td>
<td>1.54 0.25</td>
<td>0.83 0.31</td>
<td>0.71 [0.60, 0.82]</td>
</tr>
<tr>
<td>Svensson 2014</td>
<td>2.28 0.58</td>
<td>1.88 0.82</td>
<td>0.40 [0.01, 0.79]</td>
</tr>
<tr>
<td>Tanaka 2015</td>
<td>6.6 2.6</td>
<td>6.5 2.4</td>
<td>0.10 [-0.67, 0.87]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>151</strong></td>
<td><strong>189 100.0%</strong></td>
<td><strong>0.48 [0.18, 0.78]</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.05; Chi² = 6.55, df = 3 (P = 0.09); I² = 54%  
Test for overall effect: Z = 3.13 (P = 0.002)
Increased rate of complications for appendectomy compared to NOT

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Non-operative treatment</th>
<th>Appendectomy</th>
<th>Risk Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
</tr>
<tr>
<td>Armstrong 2014</td>
<td>1</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Hartwich 2015</td>
<td>0</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Minneci 2015</td>
<td>0</td>
<td>37</td>
<td>5</td>
</tr>
<tr>
<td>Svensson 2014</td>
<td>0</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Tanaka 2015</td>
<td>0</td>
<td>78</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td></td>
<td>175</td>
<td>239</td>
</tr>
</tbody>
</table>

| Total events | 1 | 9 |

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 3.52$, df = 4 ($P = 0.47$); $I^2 = 0$

Test for overall effect: $Z = 1.62$ ($P = 0.10$)
Authors’ Conclusions

- “Current data suggest that NOT is safe. It appears effective as initial treatment in 97% of children with AUA, and the rate of recurrent appendicitis is 14%.”

- The study highlights the lack of robust evidence comparing NOT with appendectomy in children

- Confirms a position of equipoise between treatment approaches

- We recommend that NOT of children with AUA be reserved for those participating in carefully designed research studies
Take-home point:

- Lap appy is still standard of care for uncomplicated appendicitis!
Once diagnosis of appendicitis has been established...

- **Non-ruptured**
  - Short duration of symptoms, no suggestion of rupture on imaging
  - Start antibiotics
  - Perform appendectomy

- **Ruptured**
  - Have radiology evaluate for drainable fluid collection
  - Antibiotics
  - Operation in acute setting if above management fails
  - Interval appendectomy 6-8 weeks later...
  - ALTERNATIVELY: Just take out the appendix!!
CT: ruptured appendix with abscess
After placement of percutaneous drain
How to counsel families of children with ruptured appendicitis

- If kids tolerate a diet, pain resolves, fever resolves → oral antibiotics and home
- Plan interval appy 6-8 weeks later
- Non-operative management may not work and surgery may be needed (Failure rate 20%)
- At home they should watch for signs of persistent/recurrent appendicitis
- High-anxiety time for patients and families
A 10-year-old boy comes to see you in the office after recent hospitalization for perforated appendicitis. He has 3 more days of antibiotics left. His mom is worried because appetite is poor and his energy level is low. On exam he has diffuse lower abdominal tenderness. You recommend:

A. Extending course of oral antibiotics
B. CT scan to evaluate for persistent or recurrent appendicitis
C. CT scan to evaluate for intra-abdominal abscess
D. Follow-up with surgeon.
Is interval appendectomy necessary?

- In adults, many surgeons do not do this operation
- In kids, data are limited:
  - 2-year follow-up of 96 patients
  - Perforated appendicitis treated non-operatively with antibiotics
  - 6 became worse; 41 had interval appendectomy
  - 49 received no further treatment
  - 57% no recurrence
  - 43% had recurrence within one month to 2 years
  - Presence of appendicolith: 72% rate of recurrence vs 26% in those without appendicolith

Approach to interval appendectomy

- More strongly recommended if fecalith present
- Observation is a reasonable option
- Best choice for an individual patient depends on their anxiety and parental anxiety
Immediate operation for ruptured appendicitis: perhaps a better option?

A systematic review and individual patient data meta-analysis of published randomized clinical trials comparing early versus interval appendectomy for children with perforated appendicitis
Meta-analysis: operative vs non-operative management of pediatric ruptured appendicitis

- 2 RCTs identified
- Total of 171 pediatric patients
- Compared early vs interval appendectomy
Early appendectomy reduced incidence of adverse event

- Blakely et al.: Odds Ratio 0.34 (95% CI: 0.16 to 0.73), P-value: 0.006
- St. Peter et al.: Odds Ratio 2.54 (95% CI: 0.34 to 18.92), P-value: 0.362
- Overall: Odds Ratio 0.51 (95% CI: 0.26 to 1.00), P-value: 0.050
Ruptured appendicitis: may have abscess or phlegmon
Early surgery was more strongly favored when there was no abscess at time of presentation.
Decreased antibiotic duration, length of stay and total charges for abscess and no abscess groups
You are seeing a 7 year old with constipation. A fecalith was seen on abdominal X ray during recent ED visit. How would you counsel the family?

A. They should be referred to surgery for appendectomy
B. Their child is at higher risk for appendicitis so they should be aware of this in case he develops symptoms
C. It is uncertain whether this child is at higher risk for appendicitis
D. A course of Miralax may help wash out the fecalith
Take home points

- **Uncomplicated appendicitis:**
  - Lap appy is still standard of care
  - Non-operative management may be an acceptable option but not enough is known about long-term risk of recurrent appendicitis

- **Complicated appendicitis:**
  - Can be managed with immediate operation, delayed appendectomy or no appendectomy
  - Immediate operation is probably more efficient and less stressful for patients and parents
Thank you very much!

- Questions?